BULLETIN No. 267 JANUARY, 1923

APPLE BLOTCH

Figure 1. Apple blotch on Northwestern variety. Blotch is the most serious disease in the southern half of Indiana on certain varieties such as Northwestern, Oldenburg, Ben Davis, Smith Cider, Maiden Blush, Mann, Benoni, Akin, Willow, Stark, Missouri, and Lawver. The right hand fruit shows severe infection about the stem end accompanied by a cracking of the flesh. Such wounds allow the entrance of black rot. Blotch can be prevented by the proper sprays and other control measures described in this bulletin.

PURDUE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION
LAFAYETTE, INDIANA.

APPLE BLOTCH

Because of its severe injury to the fruit and its increasing prevalence, blotch is the most serious disease in the southern half of Indiana on certain varieties of apples such as Northwestern, Oldenburg, and Ben Davis. Twigs, buds, and leaves are also injured.

The blotch fungus may remain alive and active seven or eight years in the cankers on the branches.

Spores of the fungus ooze out of the spore-cases during rains and are washed and spattered to leaves, fruit, and young wood, where they germinate, invade the tissues, and cause new lesions which in turn produce more spores.

Most of the infection occurs during a period of about seven weeks after petal-fall. As a rule infection does not begin before two weeks after petal-fall, but may start sooner.

From lesions on the leaf petioles the fungus grows down into the twig. Most of the cankers on bearing wood originate in this manner and become visible in the late fall or the following spring.

Many varieties are subject to fruit infection but fewer canker badly. The latter are harborers and carriers of the disease. The wild crab may also harbor the disease.

Cankers have been found in abundance on nursery stock and on seedlings used for budding purposes. Nursery row conditions are ideal for the spread of this disease.

In young plantings cankers occur on scattered trees and there seems to be little tree-to-tree infection during the first five or six years.

CONTROL

Dormant sprays were ineffective.

Dusts have given very poor control.

Bordeaux sprays applied 2, 4, and 6 weeks after petal-fall effectively prevent fruit, leaf, and twig infection.

Lime sulfur 1 to 40 is not as reliable as Bordeaux, particularly in canker control, but may be used to avoid russetting of the fruit.

Bordeaux 2-4-50 has proved as effective as the 4-6-50 formula.

If petal-fall occurs late, an additional spray soon after petal-fall is advisable, especially on Oldenburg in southern Indiana.

The sprays should be applied every year regardless of crop in order to prevent canker formation.

Orchardists should reject infected nursery stock.

Nurserymen should reject infected seedlings and should use bud sticks from sprayed or blotch-free trees. Nurserymen should apply the blotch sprays.

In young plantings blotch should be eradicated by (1) spraying annually to prevent new cankers and (2) cutting out old cankers in early spring.

Cankered branches and spurs should be pruned out.

Cankers on the trunk and large limbs are shallow and can be shaved off with a sharp knife without injury to the underlying cambium. The cuts should extend half an inch or more beyond the visible margin of the canker. No disinfectant or wound dressing seems to be necessary. Healing occurs rapidly.

Some cankers will be overlooked and a repetition of the operation the two following springs is essential.

APPLE BLOTCH

Max W. Gardner, Laurenz Greene, and Clarence E. Baker.[1]

By certain additions to the present apple spraying program and by adopting certain precautionary measures, Indiana apple growers may effectively control blotch, the serious disease of certain varieties, such as Oldenburg, Ben Davis, and Northwestern, which is causing considerable alarm because of its increasing prevalence in southern and central Indiana.

Blotch presents a striking contrast to other apple diseases such as scab and black rot, in that it is much more distinctly limited in its varietal preferences and in its geographical distribution. This disease is destructive mainly because of the large black blotches on the fruit, although leaf and twig injury also occurs.

Previous investigation of this disease has had to do mainly with the spray control of fruit infection and there is a deplorable lack of intimate knowledge of the actual behavior of the parasitic fungus which causes the disease.

It is our purpose herein to summarize briefly what is known about this disease and to present the results of our investigations of the last four years in Indiana, results which have led to the establishment of more effective principles of control.

GEOGRAPHICAL DISTRIBUTION

According to the records of the federal plant disease survey, blotch seems to be confined to the central and southern states of the eastern half of the United States including the area between New Jersey, Nebraska, Texas, and Georgia. It is primarily a disease of the southern portion of the apple belt but extends northward to central Ohio, Indiana, and Illinois and occurs here and there in the northern parts of these states. About half of the apple-producing area of the country is infested with this disease.

In Indiana the disease is at its worst in the southern end of the state. The northern limit of blotch as a serious commercial factor could be represented by a line across the state north of Indianapolis through Fountain, Montgomery, Boone, Hamilton, and Madison counties. However, the disease occurs rather commonly in the Wabash Valley and occurs to some extent further north, especially on Oldenburg and Mann in home orchards. Anderson (1) has found indications that the disease is continually encroaching northward.

---

[1]The writers are indebted to Mr. J. B. Hamer, Greenfield, Indiana, and Messrs. D. B. and Howard Johnson, Mooresville, Indiana, for active cooperation in the spray tests reported herein; to Mr. R. A. Simpson, Vincennes, Indiana, for suggestions and cooperation; to Prof. H. S. Jackson for suggestions; and to Mr. F. P. Cullinan and Mr. J. B. Kendrick for assistance rendered.

BLOTCH CAUSES HEAVY LOSS

On the susceptible varieties in the southern part of the apple belt, blotch undoubtedly has been the most serious apple disease because of the blemishing and disfiguring effects of the fruit lesions and the high percentage of fruit infection (Figs. 1, 2, 4). These blotches are also likely to crack and permit the entrance of fruit-rotting fungi (Fig. 1). In addition the abundant leaf petiole infection (Fig. 9) may cause considerable premature dropping of the leaves and the numerous leaf scar cankers may kill many of the buds on the bearing wood (Figs. 5 and 6) and may weaken or kill the twigs, especially on Oldenburg trees.

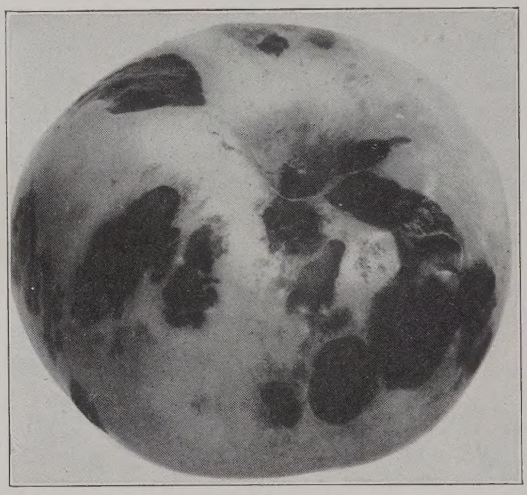

Fig. 2. Sunken lesions of blotch on Maiden Blush. This type of fruit infection is very objectionable because of its disfiguring effect and its tendency to be followed by a rotting of the fruit. Ordinarily, however, the disease does not penetrate the flesh very deeply and the lesions are rather shallow.

According to the records of the federal plant disease survey the disease causes the heaviest losses in Oklahoma, Arkansas, Mississippi, Alabama, Georgia, South Carolina, North Carolina, Tennessee, and Kentucky, in which states the loss estimates for 1920 ranged between 5 and 10 per cent of the crop or an aggregate of 4,000,000 bushels. The same year the blotch loss estimates for the rest of the affected area aggregated 1,200,000 bushels. A conservative estimate would place the annual loss in Indiana in such years as 1920 and 1922 at about 150,000 bushels.

VARIETIES DIFFER IN SUSCEPTIBILITY

One of the outstanding features of this disease is the great variation in the susceptibility of different apple varieties to blotch infection. Most of the available data has been based

upon fruit infection alone but another factor should be taken into consideration, namely, that of twig infection, to which reference will be made later.

In Indiana the following varieties are severely attacked by blotch: Northwestern, Oldenburg (Duchess), Ben Davis, Smith Cider, Maiden Blush, Mann, Benoni, Akin, Willow, Gano, and Stark. For other parts of the country, the observations of previous investigators (10; 12; 15) and the collaborators of the federal plant disease survey would add the following to this list of very susceptible varieties: Missouri, Limbertwig, Wagener, Tolman, Lawver, Fameuse, and Lansingburg. The disease has been reported on many more varieties. In Indiana the cankers have also been found on Rome, Transparent, Champion, Gideon, Rambo, Salome, Wealthy, Stayman, and Grimes and fruit lesions on York, Winter Maiden Blush, Winesap, Arkansas Black, Arkansas, Esopus, Stayman, Wealthy, Indiana Favorite, White Pippin, Jersey Black, Smokehouse, Gideon, Salome, McAfee, Kinnard, Jonathan, and Grimes.

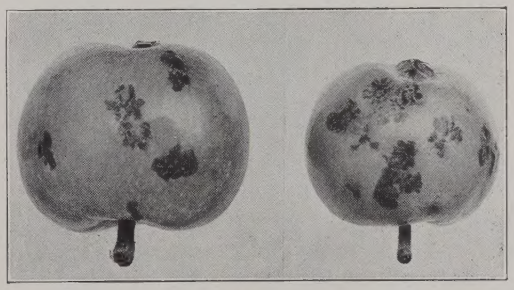

Fig. 3. Blotch lesions on young fruit of Oldenburg (Duchess) variety. This variety seems to be particularly susceptible to the disease and fruits infected in this way are practically a total loss. Blotch may obtain an early start on Oldenburg and a Bordeaux spray sooner than two weeks after petal-fall is necessary.

Possibly no varieties are absolutely immune to fruit infection but marked resistance is shown by the varieties, Grimes, Jonathan, York, Winesap, Delicious, and Stayman, all very popular in Indiana. From the commercial standpoint little trouble from blotch should be experienced with varieties not included in the list of those severely attacked of which Oldenburg is the most popular variety at present. Even the Rome and Transparent, while very subject to blotch canker, are not particularly subject to fruit infection. The blotch menace is real, however, in the case of Oldenburg and Ben Davis.

The susceptibility of a variety to canker formation is a very important consideration because the persistence of the disease from year to year depends upon this factor. In Indiana, the Northwestern and Oldenburg varieties are highly subject to canker formation,—much more so than Ben Davis and Stark.

Cankers have been found only rarely on orchard trees of Grimes and Stayman and not at all on York, Jonathan, Arkansas, and Winesap.

Cankers have been found on nursery stock of a number of varieties and on seedlings grown in the blotch regions. The wild crab-apple is also subject to blotch infection (16).

Fig. 4. Blotch lesions about stem end of fruit (Northwestern). Infection is frequently more severe about the stem end. Small lesions of this type probably result from rather late infection.

EFFECT OF BLOTCH ON THE FRUIT

The principal damage caused by this disease is due to the very objectionable and disfiguring fruit lesions. These are conspicuous shiny black blotches varying from one-eighth to one inch in diameter, irregularly lobed about the margin (Fig. 3) and often presenting a pattern composed of radiating outgrowths or projections (Figs. 1, 2, 4). These blotches may be slightly elevated or distinctly sunken (Fig. 2) and bear near the center a group of very small black points or protuberances which are the flask-like spore-cases or pycnidia (Fig. 8) containing the spores of the blotch fungus. Very young fruit lesions may be small slightly sunken spots, irregularly lobed and brown or tan-colored (Fig. 7A). Blotch lesions are most conspicuous on light colored varieties such as Northwestern, and are rather inconspicuous on dark colored varieties such as Arkansas and Lawver.

Since the fungus grows more or less continuously within the tissues, the size of the blotch depends somewhat upon the date of infection. The lesion is composed of a rather shallow superficial layer of tough black or brown tissue. The blotch fungus does not cause a rotting of the fruit, but in the case of very large

lesions (Fig. 2) or of the coalescence of several lesions (Fig. 1) cracks may be formed which permit infection of the underlying flesh by certain fruit-rotting fungi such as the black rot fungus or blue mold.

Fig. 5. Blotch cankers coalescing to form a large scurfy area on the twig. It is in these cankers that the blotch fungus persists from year to year and from these cankers infection spreads to the fruit and leaves every spring.

CANKERS ON THE BRANCHES

Young cankers first appear as dark or purplish raised spots varying in shape and bearing minute projecting points, the spore-cases or pycnidia of the blotch fungus (Fig. 6). On twigs of older trees these lesions usually extend out from some part of the leaf base or leaf scar, but on suckers, watersprouts, seedlings, and nursery stock these may be located at or between the leaf scars.

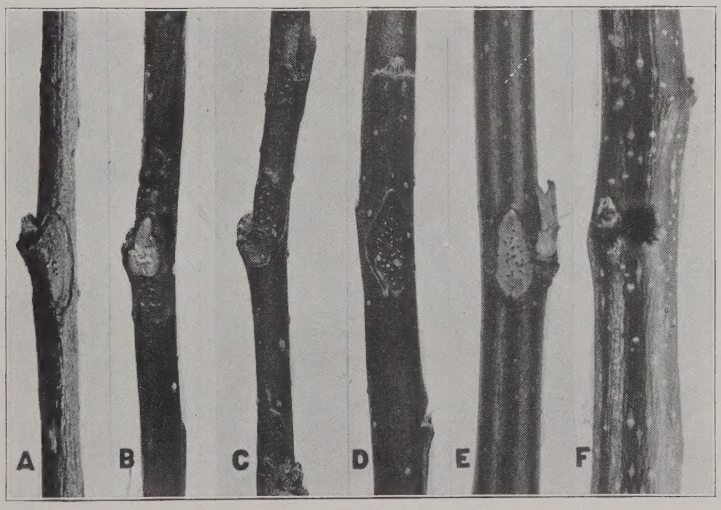

Fig. 6. Young blotch cankers.
A, B, and C. Leaf scar cankers on bearing twigs probably originating from infected leaf stems. The proper sprays prevent this type of infection.
D and E. Cankers on watersprouts showing the spore-cases or pycnidia as black or shining points. Watersprouts and suckers are especially subject to canker infection and should be pruned out every year.
F. Black leaf scar canker on nursery stock. Blotch is spread far and wide on infected nursery trees.

The center or older portion of the canker soon dries and becomes brown or tan-colored and slightly sunken, and is bordered by a crack or fissure (Fig. 6). Each canker usually increases in size for several seasons by means of raised purplish marginal extensions (Fig. 6, B and C) which produce pycnidia and then dry out and become sunken and delimited by a marginal fissure like the central flake. More than one marginal extension may be formed during the second season. By this process combined with the coalescence of a number of cankers, large scurfy areas of bark (Figs. 5, 10A, and 11A) may be produced.

On young actively growing Oldenburg and Transparent trees the cankers tend to encircle the branch (Fig. 11A) but seldom injure the cambium. Slow growing, shaded or suppressed twigs on old trees, however, may be girdled and killed by blotch infection, particularly on Oldenburg and Northwestern. Lewis (10) found that in the Missouri variety in Kansas, 28 to 42 per cent of the fruit spurs and 45 to 75 per cent of the buds on the remaining live spurs on the same branches were killed by blotch. The tendency of the cankers to occur at leaf scars results in the death of many buds.

BLOTCH ON THE LEAVES

There are two distinct types of blotch infection on apple leaves as was first noted by Sheldon (16) in 1907. On the leaf

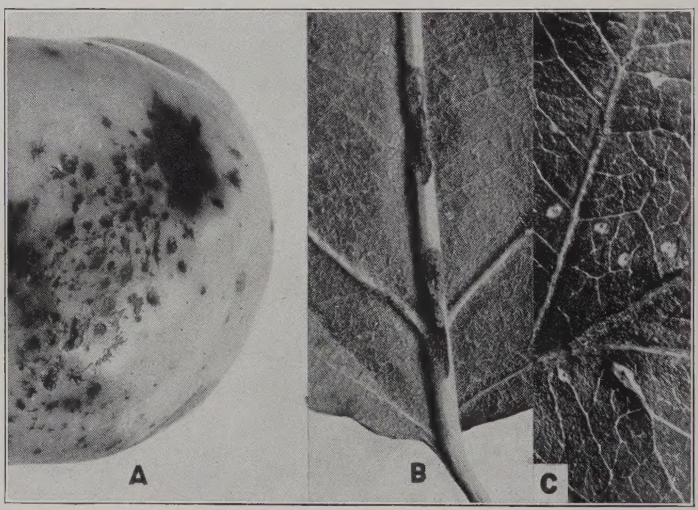

Fig. 7. A. Secondary spread of infection below an old fruit lesion indicating that the disease may continue to spread rather late in the season. The spores were probably washed by rain or dew from the old lesion.

B. Blotch lesions on the midrib, under side of leaf (X2).

C. Portion of leaf enlarged (X5) to show the whitish pin-head blotch lesions, each of which usually bears one spore-case or pycnidium at the center. (Photographed by E. J. Kohl.)

blade tissue between the veins blotch produces very small white pin-head spots (Fig. 7C) each of which bears a minute black dot in the center, the spore-case or pycnidium of the fungus. On the veins of the back of the leaf (Fig. 7B) and on the petiole or leaf stem (Fig. 9) are produced elliptical or elongated, sharply sunken, light tan or buff-colored lesions, each bearing a number of the small black pycnidia of the fungus.

Leaf infection is very heavy on the lower limbs of unsprayed trees and, while the white pin-head spots are rather harmless, the vein and petiole lesions must interfere to some extent with the translocation of the food materials and heavy infection near the base of the petiole causes many leaves to fall prematurely. In Kansas, Lewis (10) has noted severe defoliation in late summer as a result of petiole infection.

BLOTCH IS CAUSED BY A FUNGUS

Blotch is caused by a parasitic mold or fungus (*Phyllosticta solitaria* E. and E.) which by its growth within the tissues of the leaf, twig, or fruit produces the spots or lesions characteristic of the disease. When grown on artificial culture media in the laboratory this fungus produces a compact black mass of mycelium and it seems likely that the black color of the fruit blotches is due to the black color of the fungus itself. Just under the skin on the lesions are formed the small flask-shaped spore-cases or pycnidia (Fig. 8) which are packed with very small colorless one-celled spores or "seeds" of the fungus.

Fig. 8. Microscopic section through a black spore-case or pycnidium pushing through the epidermis in a fruit lesion. The pycnidium is filled with a closely packed mass of round colorless spores which, when the latter are mature, and when wet with rain or dew, will absorb water, swell, and ooze out through a hole in the top of the pycnidium. (Photomicrograph by E. J. Kohl.)

When mature pycnidia are wet with dew or rain, the closely packed jelly-like mass of spores inside absorbs water, swells rapidly, and oozes or forces itself out through a hole in the top of the pycnidium. During rains this extruded sticky mass of spores "dissolves" readily in water and the spores are separated and may be washed or splashed and blown in water drops to other parts of the tree.

INFECTION FROM SPORES

If one of these blotch spores lodges on the surface of a young leaf or fruit, it will germinate in a drop of rain or dew in a few hours by sending out an infection tube which will enter the host tissue. Here the tube grows and branches and becomes the feeding mycelium of the fungus which in a few weeks produces a visible blotch lesion. Within this lesion pycnidia and spores are soon produced, the latter to escape and spread the disease further.

Whether the germ tube penetrates the host epidermis directly or through stomata or breathing pores has not been determined. Roberts (12) has found that the fruit becomes resistant as it grows older but the occurrence of numerous small lesions on large fruit (Fig. 7A) indicates that the fruit of some varieties may remain susceptible for a considerable period. The effective prevention of infection with the sprays applied at petal-fall and two, four, and six weeks thereafter is strong circumstantial evidence that most of the blotch infection occurs during a period of seven or eight weeks immediately after petal-fall. Anderson in Illinois reports some infection occurring in late August in 1921. Pycnidia bearing mature spores can be found at all seasons so it is very likely that spores of the fungus are spread during every rain between petal-fall and autumn and that the infection period is probably determined, as Roberts (12) has suggested, by the time during which the leaves and fruit are in a susceptible condition. The exact date when infection begins is of extreme importance since the spray program must be based upon it. In 1919, 1920, and 1921 infection started later than two weeks after petal-fall, but in 1922 it began somewhat sooner in Indiana and also in southern Pennsylvania, according to Walton and Orton (18).

CANKERS ARE THE SOURCE OF INFECTION.

Orchardists should thoroughly understand the significance of the canker stage (Figs. 5 and 6) of this disease because the cankers harbor the fungus over winter and are the source of infection for the fruit and leaves in the spring. The importance of the cankers in this respect was discovered by Sheldon (16) and by Scott and Rorer (14) as early as 1907.

Scott and Rorer (15) found that the blotch fungus might live over winter in mummied fruits but did not produce spores. We have found in Indiana that the fungus also lives over winter in the petiole lesions on fallen leaves and viable spores have been found in such lesions early in the spring. However, such sources of early infection are considered unimportant.

Pycnidia bearing mature spores are present in the twig cankers early in the spring and during warm rains spores ooze from these pycnidia and are washed and splashed to the new growth of leaves and fruit and cause infection. From the resulting lesions there may be a secondary spread of infection, but most of the infection probably comes from the cankers.

Certain varieties are much more subject to blotch canker formation than others and it is these varieties that are particularly dangerous as harborers of the disease when present in orchards of mixed varieties. In Indiana the varieties Northwestern, Oldenburg, and Mann are serious offenders in this respect. For example, a single row of Northwestern has been observed to be the source of fruit infection for a large orchard containing a number of varieties.

Suckers and watersprouts are especially subject to the canker stage of the disease and therefore should be cut out. Cankers may also occur on the wild crab-apple which should be considered a dangerous neighbor of apple orchards. The significance of cankers on nursery stock and seedlings is discussed in a later paragraph.

CANKERS LIVE MANY YEARS

Lewis (10) has found that the fungus dies out or at least ceases to produce spores in the older central portions of the canker when these dry out during the second season but that it may live and grow three or four years in the advancing margin of the canker and continue to produce spores therein (Fig. 6, B and C). Roberts (12) has made somewhat similar observations.

In the fall of 1921, small pieces of bark tissue were cut from the advancing edges of cankers of various ages on Oldenburg, sterilized a few minutes in a corrosive sublimate solution, rinsed, and planted in agar poured plates. By the characteristic outgrowth of the blotch fungus from these plantings, it was found to be alive in cankers on limbs five, seven, eight, and even 14 years old. Furthermore, the fungus continues to produce pycnidia and spores in the advancing margin of these cankers. However, since limb cankers may result from infected spurs, the cankers are not necessarily as old as the limb.

TWIG CANKERS RESULT FROM INFECTED LEAF STEMS

Because of the great importance of the cankers, a study of their mode of origin has been made (7). Roberts (12; 13) produced cankers on very young twigs by inoculation with blotch spores and has shown that twigs are susceptible only during their first season. It seems likely that all of the lesions located between leaf scars are due to direct infection from spores. Such lesions are very abundant on suckers and watersprouts (Fig. 6D) which do not harden and mature as early as ordinary twigs and also on nursery stock.

However, on Northwestern it has been noted that about 90 per cent of the twig cankers are located at leaf scars (Fig. 6) and the majority of these cankers do not become visible until late fall of the first season or the spring of the second year. It has been shown (7) that such cankers are the result of the fungus crossing over to the twig from basal petiole lesions on the leaves (Fig. 9). Consequently the control of petiole infection is essen-

tial in canker prevention. Fortunately, the spraying program which has given control of the disease on the fruit also has afforded control of leaf petiole infection and as a consequence

Fig. 9. Blotch lesions on leaf petioles. From such lesions the fungus grows down into the twig and later forms a canker at the leaf scar, which appears in the fall or following spring. Petiole infection is prevented by the same sprays that prevent fruit infection and by spraying every year, regardless of crop, canker production can be entirely prevented. The fungus may remain alive in these petiole lesions in fallen leaves over winter.

cankers have been prevented. The practical significance of this relationship is the necessity for applying the blotch sprays every year to young trees as well as old, regardless of crop, to prevent leaf infection and subsequent canker formation. Scott and Rorer (15) noted that the fruit sprays also protected the twigs, and, as others have pointed out, thorough spraying every year to prevent canker formation should tend to eradicate the disease from the tree, or at least greatly to minimize the blotch danger. Spray trials now in progress indicate that canker formation can be effectively prevented.

DEVELOPMENT OF A SPRAY CONTROL

Fortunately, it was found very early in the study of apple blotch, that fruit infection could be prevented by a fungicidal spray such as Bordeaux mixture. The principle of such a spray is that the leaves, fruit, and twigs are covered with a thin layer or film of the spray material before infection occurs so that when

a blotch spore lodges in a drop of rain or dew on the surface of an apple, for example, enough of the toxic substances of the spray coating are dissolved in the water drop to kill the spore or its germ tube before the latter has time to penetrate the skin of the fruit. After the germ tube enters the fruit tissue, no amount of spraying will prevent the appearance of a blotch lesion. Investigation along this line of blotch control has dealt mainly with date of application and character of the fungicide to be used.

One of the outstanding features has been the progressive changes in the spray recommendations aiming at an earlier application of the sprays. The first recommendation, made in 1907, called for four Bordeaux sprays beginning six weeks after petal-fall and two years later this schedule was revised (15) so that the first spray was applied three or four weeks after petal-fall in the Ozark region. Lewis (10) in Kansas found applications made 3, 5 to 7, and 10 weeks after petal-fall effective on the Missouri variety. Roberts (12) found that for the Ozark region a 3-, 6-, and 9- weeks (after petal-fall) schedule was advisable. Gunderson (9) working with Ben Davis in Illinois adopted a 3-, 5-, and 7- weeks schedule, and showed that the 3- and 5- weeks sprays were all-important from the standpoint of blotch control. Beach (2) obtained excellent control on Ben Davis, Smith Cider, and Oldenburg in southern Ohio with a 2-, 4-, 6-, and 10- weeks schedule, and Brock (4; 5) has found that for Oldenburg in southern Illinois a 2-, 3-, 4-, 5-, and 7- weeks schedule was advisable. Both determined that the early applications were by far the most important.

There has been some difference of opinion as to the best spray material to use. Scott and Rorer (15) first recommended a 4-6-50 Bordeaux. Lewis (10) advised a 3-4-50 Bordeaux for Kansas conditions and found that lime sulfur was not as effective. Roberts (12) suggested the use of lime sulfur, 1½ to 50, in cases of mild infection. Because of the injury caused by Bordeaux during cool wet weather to such varieties as Ben Davis, there is much objection to its use, particularly early in the season, and under such circumstances lime sulfur would be preferable if it were reliable. Gunderson (9) found that sulfur dust was of little value and that lime sulfur, 1¼ to 50, gave as good results as Bordeaux, except in 1916, and recommends its use. Brock (4) obtained similar results with lime sulfur and also recommends its use. Beach (2) recommends Bordeaux 3-5-50 for Ohio conditions.

Wallace (17) suggested that dormant sprays of 10° lime sulfur might control blotch. Gunderson (9) found that dormant sprays of copper sulfate, Scalecide, and lime sulfur were ineffective against the disease, and Brock (3) found that strong lime sulfur was likewise ineffective but more recently (5) has reported some benefit from a delayed dormant spray of double strength lime sulfur.

SPRAYING TESTS IN INDIANA

To verify or supplement for Indiana conditions the more recent spraying recommendations discussed in the preceding paragraphs, spraying tests were carried out during 1919 to 1922 in central Indiana at Mooresville (Morgan county) in cooperation with Mr. D. B. Johnson and Mr. Howard Johnson, and at Knightstown (Henry county) in cooperation with Mr. J. B. Hamer, and in southern Indiana at Mitchell (Lawrence county) in the Experimental orchard.

At Mooresville, two parallel rows, one of 11 Northwestern trees badly infested with blotch cankers, and one of 15 Stark trees not badly cankered, were used in 1919 to test the value of a dormant spray of 10° lime sulfur and in 1920 and 1921 were divided into four plots for a comparison of Bordeaux spray, Bordeaux dust, and sulfur dust applied 2, 4, and 6 weeks after petal-fall.

At Knightstown a block of 46 Northwestern trees severely infested with blotch cankers was used to test dormant sprays in 1919, 1920, and 1921 and lime sulfur and Bordeaux summer sprays in 1920, 1921, and 1922.

At Mitchell a block of 31 badly diseased Oldenburg trees was divided into six plots in 1921 and 1922 to test various summer spray schedules. Arsenate of lead was added to the summer sprays at Knightstown and Mitchell.

The control of blotch was ascertained by determining the percentages of fruit infection at harvest time according to the following arbitrary classification:

"No blotch"—fruit absolutely free from blotch lesions.

"Slight blotch"—first grade marketable fruit bearing not more than six very small blotch lesions.

"Serious blotch"—fruit bearing one or more large blotch lesions or more than six small lesions.

The percentage of petiole infection was also determined. The results of these spray trials are presented under the six following sub-titles.

DORMANT SPRAYS

Considerable interest has been aroused among orchardists relative to the possibility of controlling blotch with a dormant spray of concentrated lime sulfur. The results obtained in 1919 at Mooresville with a dormant spray are shown in table I.

Table I. Dormant Spray, Northwestern Variety, Mooresville, 1919

Treatment	Number of fruits examined	Percentage control		
		No blotch	Slight blotch	Serious blotch
Lime sulfur 1 to 3	1,071	8	20	72
None	1,368	7	25	68

No control was obtained in this test with the concentrated lime sulfur.

The results obtained in 1919 at Knightstown with dormant applications are shown in table II.

Table II. Dormant Spray, Knightstown, 1919

Treatment	Number of fruits examined	Percentage control		
		No blotch	Slight blotch	Serious blotch
Lime sulfur 1 to 3	1,815	14	22	64
Dry lime sulfur, 25 lbs. to 50 gals.	1,911	18	25	57

Unfortunately, no unsprayed trees were left but the high percentage of blotch shows that little or no control was obtained with either the liquid or dry lime sulfur.

The results obtained at Knightstown in 1920 with dormant sprays of lime sulfur applied April 20 are shown in table III.

Table III. Dormant Sprays, Knightstown, 1920

Treatment	Number of fruits examined	Percentage control		
		No blotch	Slight blotch	Serious blotch
Lime sulfur 1 to 3	792	13	17	70
Lime sulfur 1 to 8	516	16	26	58

The strong lime sulfur gave no better control than the ordinary dormant strength and neither appeared to influence the disease. The results obtained in 1921 with dormant sprays applied March 22 are shown in table IV.

Table IV. Dormant Sprays, Knightstown, 1921

Treatment	Number of fruits examined	Percentage control		
		No blotch	Slight blotch	Serious blotch
Lime sulfur 1 to 3	715	12	15	73
Lime sulfur 1 to 8	1,122	11	19	70
Copper sulfate, 2 lbs.—50 gals.	1,176	11	18	71

From the results in table IV it is evident that dormant applications of a copper sulfate solution and of strong lime sulfur were ineffective in blotch control. These results tend to substantiate the conclusions of Gunderson (9) and the earlier conclusions of Brock (3) to the effect that dormant sprays are of little value in blotch control,—too little in fact to warrant the expense of the strong lime sulfur.

Tests made in Indiana in 1919 and also by Guba (8) in Illinois have shown that strong lime sulfur may kill the spores already present in the pycnidia or spore-cases of the blotch fungus in the cankers. However such a spray will not check the growth of the fungus within the bark tissues nor prevent the continued production of new spores.

POOR CONTROL WITH DUSTS

The comparative effectiveness of sulfur dust, Bordeaux dust, and a Bordeaux spray applied 2, 4, and 6 weeks after petal-fall (May 13) at Mooresville in 1920 is presented in table V.

Table V. Dusts vs. Spray, Mooresville, 1920

Variety	Treatment	Number of fruits examined	Percentage control		
			No blotch	Slight blotch	Serious blotch
Northwestern	Bordeaux 4-6-50[1]	2,471	64	28	8
	Sulfur dust	2,517	53	31	16
	Bordeaux dust	1,265	31	44	25
	None	1,684	9	25	66
Stark	Bordeaux 4-6-50	2,020	72	19	9
	Bordeaux dust	348	32	32	36
	None	557	35	37	28

[1]Bordeaux mixture, 4 lbs. copper sulfate, 6 lbs. hydrated lime, 50 gal. water.

From the results in table V it appears that sulfur dust is somewhat more effective than Bordeaux dust in controlling fruit infection but that neither are as effective as the Bordeaux spray. Somewhat similar results on the Ben Davis variety were obtained by C. L. Burkholder, Extension Specialist, at Solon in southern Indiana, the same season. The use of Bordeaux dust yielded 25 per cent of fruit free from blotch, the spray, 83 per cent, and the check trees, 3 per cent.

In 1921 the tests were repeated at Mooresville, and due to the absence of fruit that season the control of petiole infection as shown in table VI must serve to indicate the effectiveness of the treatments.

Table VI. Dusts vs. Spray, Mooresville, 1921. Northwestern.

Treatment (2, 4, and 6 weeks)	Petiole infection	
	Number examined	Percentage infected
Bordeaux 4-6-50	2,067	4
Sulfur dust	283	35
Bordeaux dust	184	50
None	611	94

These results indicate that the dusts are not effective in controlling petiole infection, and, since twig infection largely results from petiole infection, the dusts could not be depended upon in a canker eradication program.

Both sulfur and Bordeaux dusts gave an unsatisfactory control of fruit infection and consequently can not be recommended as blotch control measures.

BORDEAUX EFFECTIVE; LIME SULFUR NOT AS RELIABLE

The results already presented in tables V and VI show that the Bordeaux sprays at 2, 4, and 6 weeks after petal-fall gave a good control of blotch. The results obtained at Knightstown and Mitchell and presented in the following tables prove the effectiveness of the Bordeaux summer sprays and substantiate for Indiana conditions the results obtained in other states.

The sprays at Knightstown in 1920 were applied June 5, June 21, and July 5, petal-fall having occurred May 22. The results are presented in table VII.

Table VII. Spray Control, Knightstown, 1920. Northwestern

2, 4, and 6 weeks spray	Number of fruits examined	Percentage control (fruit)			Petiole infection	
		No blotch	Slight blotch	Serious blotch	Number examined	Percentage infected
Bordeaux 4-6-50	1,386	88	9	3	3,371	0.3
Lime sulfur 1 to 40	172	78	19	3	1,220	0
None	970	13	21	66	2,555	28

The effectiveness of the 4-6-50 Bordeaux applied 2, 4, and 6 weeks after petal-fall against both fruit and petiole infection is apparent from the data in table VII, and the results obtained with lime sulfur 1 to 40 applied at the same intervals were very promising. Because of the fruit injury often resulting from the Bordeaux, it was thought that possibly the lime sulfur could be used in its place, a procedure recommended by Brock (4) in Illinois. But results later obtained have greatly modified this view.

In 1921, petal-fall occurred at Knightstown on April 30 and the blotch sprays were applied May 13, May 27, and June 10. The results are presented in table VIII.

Table VIII. Spray Control, Knightstown, 1921. Northwestern

2, 4, and 6 weeks spray	Number of fruits examined	Percentage control (fruit)			Petiole infection	
		No blotch	Slight blotch	Serious blotch	Number examined	Percentage infected
Bordeaux 4-6-50	2,107	80	14	6	2,632	0.4
Lime sulfur 1 to 40	1,502	53	28	19	2,696	8.5
None	2,240	13	16	71	3,717	40.0

These results prove further the effectiveness of the 4-6-50 Bordeaux and show that, contrary to the indications of the previous year, lime sulfur can not always be relied upon to give a good control of blotch, since the control of fruit infection was unsatisfactory and the occurrence of 5 to 11 per cent of petiole infection would result in at least a few cankers, as was actually noted the following year. However, the fruit sprayed with lime

sulfur had a smoother finish than the fruit sprayed with Bordeaux and was free from spray injury.

There was a slight rearrangement of the plots at Knightstown in 1922 and two of the former check rows were sprayed with Bordeaux and one with lime sulfur. However, there was no evidence that the disease was more effectively controlled in the rows sprayed during the two preceding years than in these rows that had not been sprayed previously. The petals fell very late (May 6) at Knightstown and the blotch sprays were applied May 18, June 5 and 6, and June 16. The results are presented in table IX.

Table IX. Spray Control, Knightstown, 1922. Northwestern

2, 4, and 6 weeks spray	Number of fruits examined	Percentage control (fruit)			Petiole infection	
		No blotch	Slight blotch	Serious blotch	Number examined	Percentage infected
Bordeaux 4-6-50	4,589	75	9	16	2,409	22
Bordeaux 2-4-50	4,643	76	10	14	2,261	23
Lime sulfur 1 to 40	4,901	75	9	16	2,035	46
None	2,393	5	6	89	2,099	84

Some of the results in table IX were surprising and to a certain extent disappointing. The control of both fruit and leaf infection obtained with the standard strength Bordeaux was rather poor compared with the previous years. The weaker Bordeaux seemed to be fully as effective as the standard strength. The rather unsatisfactory control may be accounted for in part by the fact that the application of the two weeks spray was made difficult by high winds followed by showers. However, results obtained at Mitchell indicate that the main reason for the failure was that a spray two weeks after petal-fall was not early enough in 1922.

There was a marked difference in the response of individual trees to the same treatment, particularly the lime sulfur. On three trees lime sulfur gave a better control of fruit infection than Bordeaux, but on two other trees the control of both fruit and leaf infection was very unsatisfactory. The failure of lime sulfur to control petiole infection means that it is not as reliable as Bordeaux in a "clean up" campaign aiming at canker prevention. On the fruit sprayed with lime sulfur there was considerable late infection in the shape of numerous very small lesions (Fig. 7A).

As to spray injury, the fruit sprayed with lime sulfur had a smoother finish than the fruit sprayed with Bordeaux but

typical lime sulfur injury occurred on a few fruits exposed to the hot afternoon sun.

An important feature in connection with all sprayed plots which the numerical data fails to show is that much of the fruit from sprayed trees included under "serious blotch" was much less severely injured than the same class from the check trees and consequently represents relatively less economic loss. There is no question as to the value and necessity of the blotch sprays from the commercial point of view.

LIME SULFUR NOT EFFECTIVE ON OLDENBURG

The results obtained on the Oldenburg variety in southern Indiana have served to indicate more clearly the relative unreliability of lime sulfur and the suitability of a weaker Bordeaux and have revealed some new points relative to the effect of an earlier spray application. Owing to the failure of the fruit crop at Mitchell in 1921 it is necessary to depend upon the control of petiole infection for a measure of the effectiveness of the sprays, as shown in table X.

Table X. Spray Control, Mitchell, 1921. Oldenburg.

Sprays at petal-fall and 2, 4, and 6 weeks	Number of leaves examined	Percentage infected
L. S. petal-fall; 4-6-50 Bor., 2, 4, 6 weeks	1,120	3.3
2-4-50 Bor., petal-fall, 2, 4, 6 weeks	1,245	1.7
L. S. petal-fall; 2-4-50 Bor., 2, 4, 6, 10 weeks	2,288	1.9
L. S. all sprays	1,196	26.0
None	1,206	93.0

Bor.—Bordeaux. L. S.—Lime sulfur, 1 to 40.

In the control of petiole infection the effectiveness of the Bordeaux sprays is again illustrated in table X. The outstanding points are the very poor control obtained with the lime sulfur and the surprisingly good results obtained with the weaker (2-4-50) Bordeaux. The effectiveness of an intermediate strength of Bordeaux (3-5-50) was also demonstrated in 1921 at Solon in southern Indiana by C. L. Burkholder, Extension Specialist. In a total of 2182 leaves from sprayed trees no petiole infection was found, while out of 893 leaves from unsprayed trees, 88 per cent were infected.

The additional spray at Mitchell ten weeks after petal-fall in 1921 seemed to be entirely unnecessary and, furthermore, there seemed to be no particular benefit from the use of Bordeaux for the petal-fall spray, but the next season the results in this connection were distinctly different.

The petals fell at Mitchell on April 21, 1922, and due to an accident, the two weeks spray was applied three days late (May 8). The other sprays were applied May 17 and May 31. A good crop of fruit made it possible to obtain satisfactory counts. The blotch infection on the unsprayed plot was very severe and the fruit had dropped off to a much greater extent than in the sprayed plots when the counts were made (July 10). The results are summarized in table XI.

Table XI. Spray Control, Mitchell, 1922. Oldenburg.

Sprays at petal-fall and 2, 4, and 6 weeks	Number of fruits examined	Percentage control		
		No blotch	Slight blotch	Serious blotch
No petal-fall; 4-6-50 Bor., 2, 4, 6 weeks	3,297	21	13	66
L. S. petal-fall; 4-6-50 Bor., 2, 4, 6 weeks	5,029	45	19	36
L. S. petal-fall and 2 wks.; 4-6-50 Bor., 4, 6 weeks	4,339	44	21	35
L. S. all sprays	4,191	27	16	57
2-4-50 Bor. all sprays	4,334	91	7.5	1.5
None	2,770	4	6	90

The results in table XI show that, strangely enough, Bordeaux was not superior to lime sulfur for the two weeks spray while it was distinctly superior for the two later sprays.

EARLY SPRAY IMPORTANT

The outstanding feature of the 1922 tests on Oldenburg as shown in table XI is the great importance of the early (petal-fall) Bordeaux spray for blotch control. It should be remembered that the two weeks spray was three days late. In the plot where no petal-fall spray was applied, the 2-, 4-, and 6- weeks applications of Bordeaux resulted in very poor control while the lime sulfur petal-fall spray doubled the percentage of clean fruit and the weak Bordeaux at petal-fall gave an almost perfect control. However, severe russetting of the fruit was noted as early as May 31 in the plot receiving this petal-fall spray of Bordeaux.

Owing to a difference in the date when the petals fell, the two weeks spray in 1922 was applied six days later at Knightstown and eleven days later at Mitchell than in 1921, when better control was obtained. A comparison of the weather conditions of the two years fails to justify such a difference in spray dates.

The blossoming period was much protracted in 1922 and this evidently made the petals fall abnormally late so that the two weeks spray was too late to prevent early infection. In this connection it is of interest to note that Walton and Orton (18) estimate that blotch infection began as early as 10 days after petal-fall in southern Pennsylvania in 1922.

In view of the 1922 results it would seem advisable to apply an additional blotch spray very shortly after petal-fall on early varieties in southern Indiana particularly in seasons when the blossoming period is late or greatly protracted. This spray should be applied in advance of any warm rains after petal-fall and should be followed by the 2-, 4-, and 6- weeks applications.

The Simpson Orchard Company at Vincennes has applied the first blotch spray of 2-4-50 Bordeaux on young Oldenburg trees very soon after petal-fall and has consistently prevented infection. In 1922 this spray caused considerable burning of leaves and young shoots but such injury was not considered serious.

The danger of Bordeaux spray injury to the fruit of such varieties as Ben Davis and Oldenburg resulting from the earlier applications, which are likely to be applied during cool rainy weather, presents a problem as yet unsolved. Lime sulfur is not a reliable substitute, and even the 2-4-50 Bordeaux causes some degree of injury. It is possible that a Bordeaux weaker than 2-4-50 may be safe and effective.

To summarize briefly the results of the spray tests it may be said that (1) dormant sprays exerted no control, (2) dusts gave only a partial control, (3) Bordeaux gave good control, (4) lime sulfur was not as reliable as Bordeaux, (5) a weak Bordeaux seemed to be reliable, (6) a spray earlier than two weeks after petal-fall is necessary in certain seasons, (7) Bordeaux caused some russetting, (8) the sprays were more beneficial from the commercial standpoint than the figures would indicate, and (9) thoroughness of application is essential.

SPRAY CONTROL OF LEAF AND TWIG INFECTION

An examination of the data in tables VII, VIII, and IX will show that the percentage control of petiole infection by the various sprays is very nearly proportional to the control of fruit infection obtained. In other words, the sprays which prevent fruit infection also prevent petiole infection.

The origin of cankers from petiole lesions has been described previously. That the sprays which prevent petiole infection also prevent twig infection is shown in tables XII and XIII.

The excellent control of petiole infection is shown by a comparison of the negligible percentage of infection on the sprayed trees with the high percentage of infection on the unsprayed check trees. Furthermore these particular sprayed trees showed a high percentage of petiole infection in 1919, the year before the spraying was begun.

Table XII. Spray Control of Leaf and Twig Infection, Knightstown, 1920. Northwestern

2, 4, and 6 weeks sprays	Petiole infection		Twig infection on 1920 wood		
	Number examined.	Percentage infected	Number examined	Percentage infected	Cankers per 100 twigs
Bordeaux, 4-6-50	2,173	0.3	227	0	0
Lime sulfur, 1 to 40	1,037	0	129	0.8	0.8
None	1,454	37.5	214	62.5	126

The almost perfect control of twig infection is apparent from a comparison of the canker counts made on the 1920 wood of sprayed and unsprayed trees. Furthermore, cankers were abundant on the 1919 wood, so their absence on 1920 wood is obviously due to the spray applications of that year. Most of the cankers on the 1920 wood did not become visible until 1921 and the records were taken in 1921. All were located at leaf scars and, as has been shown elsewhere, such cankers were the result of fungous invasion from the basal petiole lesions. Consequently the absence of cankers on the sprayed trees is the direct result of the spray control of petiole infection in 1920.

Judging from the results obtained with the lime sulfur sprays it would appear that in 1920 this material controlled leaf and twig infection fully as well as Bordeaux. But in 1921 different results were obtained as is shown in Table XIII.

Table XIII. Spray Control of Petiole and Twig Infection, Knightstown, 1921. Northwestern

2, 4, and 6 weeks sprays	Petiole infection		Twig infection on 1921 wood		
	Number examined.	Percentage infected	Number examined	Percentage infected	Cankers per 100 twigs
Bordeaux, 4-6-50	1,660	0.11	200	0	0
Lime sulfur, 1 to 40	2,696	8.6	206	3.9	4.8
None	1,154	68.8	101	82	546

The petiole infection was much heavier on the unsprayed trees in 1921 than it was in 1920, but almost perfect control of petiole and twig infection was afforded by the Bordeaux sprays. The lime sulfur permitted 8.6 per cent of petiole infection and consequent twig infection which was determined the following season. Therefore, from the standpoint of canker eradication lime sulfur was not as reliable as Bordeaux.

The spray control of petiole infection on Oldenburg in 1921 was shown in table X. The lime sulfur permitted 26 per cent of petiole infection while the Bordeaux gave an almost perfect control. Very heavy infection (93 per cent) occurred in the unsprayed trees. The 2-4-50 Bordeaux proved as effective as the stronger mixture. An additional spray at 10 weeks after petal-fall proved unnecessary.

In summary it may be said that the Bordeaux sprays which control fruit infection likewise control petiole and consequently twig infection. Therefore, the application of these sprays every year regardless of crop should lead toward complete eradication of the disease. In such a program lime sulfur is not as reliable as Bordeaux.

BLOTCH ON NURSERY STOCK AND SEEDLINGS

Because of the large and increasing acreages of young commercial orchards in southern Indiana certain new phases of blotch control have received attention (7). Inspection of young orchards of such varieties as Oldenburg, Transparent, and Rome has revealed that blotch cankers are frequently present on the trunks and main limbs of a varying percentage of these young trees. The fact that these infected trees were scattered here and there through an orchard at once suggested that the disease had come in on the nursery stock and subsequent observations fully confirmed this suspicion.

M'Cormack (11) reported blotch on nursery stock in Indiana in 1910, and the same thing has been noted in Iowa. The cankers have been found in abundance on nursery stock of the susceptible varieties such as Benoni and even on the less susceptible Rome. In a large shipment of nursery trees from Oklahoma, blotch cankers were very abundant on both stock and scion (Fig. 10, B and C) and the consignee wisely rejected the shipment. In young Grimes trees double-worked on Northwestern stock, F. P. Cullinan has found cankers on the Northwestern portion of the trunks. Orchardists should reject all infected nursery stock and demand blotch-free trees.

Furthermore, apple seedlings imported from Kansas for budding stock were found heavily infested with blotch cankers (Fig. 10A). After these were budded, cankers were present both above and below the inserted bud and even on the root so

Fig. 10. Blotch cankers on nursery stock.

A. Budded seedling heavily infected with blotch cankers. This seedling was one of a badly infected shipment imported into an Indiana nursery from another state. Indiana nurserymen should guard against the use of such seedlings, which not only result in infected nursery trees, but also introduce the disease into the nursery row where conditions for the spread of blotch are ideal.

B and C. Nursery stock showing old blotch cankers on the stock and younger cankers on the scion. It is in this form that blotch is carried far and wide and introduced into young orchards. Orchardists should reject infected nursery stock.

that, not only was the scion exposed to infection, but there were cankers on that portion of the seedling which remains a part of the final tree. Blotch may be introduced into nurseries with the seedlings and nurserymen should reject shipments containing infected seedlings.

The nursery row affords ideal conditions for the tree-to-tree spread of a water-borne fungus such as this. Consequently it is highly advisable for nurserymen and seedling growers to apply the blotch sprays. Nurserymen should bear in mind that buds cut from susceptible varieties may carry invisible blotch infection in the tissue about the leaf scar unless these buds are obtained from sprayed or blotch-free trees.

CANKER ERADICATION IN YOUNG ORCHARDS

The history of blotch in an orchard would appear to be introduction in the canker stage on the nursery stock and subsequent formation each season of new cankers higher up in the trees originally infected until, by the time such trees begin to bear, there are cankers high enough to permit of drip infection of the fruit during rains. In badly infected trees, cankers are always more abundant on the lower limbs. In old or closely planted orchards there is evidence of considerable tree-to-tree spread of the disease, but in young orchards where the trees are well separated there seems to be very little spread from one tree to another For example, in a block of 156 Oldenburg trees planted in 1918 and inspected in 1922 and 1923, 37 per cent contained no cankers. Older trees of the same age and variety show distinct individuality as to the severity of blotch and it seems reasonable to suppose that the most severely diseased trees were those which were infected when young.

Since the fungus may remain alive and active in the cankers many years and since the number of cankers increases every year, the question at once arises, "Why allow this reservoir of infection to accumulate in young orchards?" It seemed highly desirable to locate and cut out these perennial sources of infection and in cooperation with the Simpson Orchard Company of Vincennes, an extensive field test of the feasibility of blotch eradication from young orchards of Oldenburg and Transparent has been instituted (7). There are two distinct phases of this campaign, one the application of the Bordeaux blotch sprays in these young orchards every year to prevent leaf infection and the formation of new cankers, and the other, the eradication of the old cankers already present.

Elimination of the blotch cankers from young trees proved to be a comparatively simple process. Many were removed by pruning out spurs and smaller limbs, but on larger limbs the cankers were cut out with a sharp knife. The fungus penetrates only about half way through the bark and the infected bark can be shaved off without any injury to the underlying cambium. If this operation is performed in early spring, healing occurs

Fig. 11. Method of cutting out blotch cankers in young trees.

A. Typical encircling canker on Oldenburg. The infection is shallow, however, and does not penetrate to the cambium.

B. Canker shown in A has been cut out with a sharp knife. The cut is deep enough to remove all of the brown infected tissue, but not deep enough to injure the cambium, and extends well beyond the visible margin of the canker.

C. Crotch cankers are more difficult to remove, but canker eradication to be effective must be thorough. By cutting out the old cankers and spraying to prevent new cankers, young orchards may be kept free from blotch.

rapidly, the cuts become mere scars in the bark, and there is no injury to the tree. Furthermore, the cankers are more easily detected before the leaves appear.

It is essential to cut deeply enough to remove all of the discolored bark and to extend the cut about half an inch beyond the visible margin of the canker in order to remove all of the fungus (Fig. 11) and prevent renewal of the fungous growth about the edges of the cut. This precaution is particularly important as applied to the sides of the canker since the latter tends to encircle the branch, and the cut should be extended three-quarters of an inch beyond the canker margin at these points.

In some cases a coating of melted paraffin was applied to the cuts but this proved unnecessary. It appears that there is no necessity of using a disinfectant wash or a wound dressing, at least on young trees. Fire blight was prevalent in the trees operated upon but no infection of the wounds was noted.

In a block of Oldenburg and Transparent trees set out in 1918 the cankers were removed early in April, 1922, again in November, and again in April, 1923. The reinspection of the trees and repetition of the process proved absolutely essential because of the many cankers that were overlooked or invisible at first. Since this plot had received the blotch sprays in 1921 and 1922, few new cankers appeared. Cankers were found in 63 per cent of the 156 Oldenburg trees and 88 per cent of the 61

Transparent trees. From the Oldenburg trees about 90 cankered limbs were pruned out and a total of 379 cankers were shaved off. From the Transparent trees 4 cankered limbs were cut off and 172 cankers shaved off. Most of the cankers on Transparent trees were on the trunks.

The reinspection made in April, 1923, showed only a very few cases of renewal of fungous growth at the sides of the earlier cuts. The wounds had healed perfectly and were mere surface scars in the bark. No injury to the trees had occurred. These results indicate that canker excision is safe and effective. However, a very careful search is necessary to locate all of the cankers and the process must be repeated the next two seasons to detect the cankers overlooked. Cankers on short spurs and about their bases are easily overlooked.

In April, 1922, canker eradication was carried out on an extensive scale by the Simpson Orchard Company in an orchard of about a thousand Oldenburg trees planted in 1917 and sprayed for blotch in 1920, 1921, and 1922. It was found that workmen

Fig. 12. Result of cutting out blotch cankers in a young Oldenburg tree. The cuts, made in April and photographed in November, had become mere surface scars in the bark and no reinfection had occurred. The paraffin coating was unnecessary. One canker was overlooked as indicated by the fresh cut. Because cankers are easily overlooked, reinspection and repetition of the process are necessary during subsequent seasons. This work should be done early in the spring.

could be readily trained to do the work successfully. In November, 217 of these trees were examined (Fig. 12) and it was found that more than half of the 152 trees operated upon were apparently free from cankers and that cankers had been overlooked in 78 trees. However, the majority of the cankers had been removed and there were not many cases of marginal renewal of fungous growth about the cuts. A repetition of the process is of course necessary. This method of canker eradication seems highly promising.

A Kansas orchardist, Mr. Wm. Freienmuth (6), recently reported good success in cutting out blotch cankers in a 20-year-old orchard of Ben Davis and Missouri and strongly advocates canker eradication. He began his work in the fall of 1919 and employed somewhat the same methods advised above, except that the wounds were treated with a Bordeaux wash.

The necessity of spraying young trees of the susceptible varieties every year can not be over emphasized. To fail to spray even one season gives the fungus a chance to form a new crop of cankers. Thoroughgoing canker eradication combined with annual application of the blotch sprays should eliminate the disease from young orchards and prevent it from becoming a serious problem.

RECOMMENDATIONS FOR BLOTCH CONTROL.

Apple blotch is successfully controlled by a 4-6-50 or 2-4-50 Bordeaux spray applied 2, 4, and 6 weeks after the petals fall. If the spray schedule generally recommended for apples is followed, this will necessitate only two extra applications, the four and six weeks sprays, since the two weeks or first blotch spray will, with the addition of arsenate of lead (one pound powder or two pounds of paste), substitute for one of the sprays applied for scab and insect control. This spray should in no case be applied later than two weeks after petal-fall.

Under certain conditions, especially when petal-fall occurs abnormally late, an additional earlier spray right after petal-fall is necessary to control blotch. This holds true particularly for early varieties in southern Indiana. The scab spray of 1° lime sulfur usually applied just after petal-fall may be depended upon for a partial control of blotch, but a 2-4-50 Bordeaux is much more effective. The revised schedule would then include four sprays. The weaker 2-4-50 Bordeaux apparently may be safely substituted for the standard strength in all of the blotch sprays.

If the danger of Bordeaux injury to the fruit is a serious consideration as in the case of Ben Davis, 1° lime sulfur may be substituted for the Bordeaux in all of the sprays, or in the earlier sprays alone. Lime sulfur is not as reliable as Bordeaux where the disease is serious, nor in cases where a clean-up program involving canker control is desired, but will give a fair control of fruit infection.

Too much emphasis can not be placed upon the necessity of thoroughness of application of the blotch sprays. A fine mist applied at 200 to 250 pounds pressure will give a more even distribution of the material than a coarser spray. Needless drenching should be avoided as this not only wastes material, but also causes excessive spray injury. The entire surface of the leaves, fruit, and young wood should receive a protective covering of the fungicide, and to accomplish this some systematic method of spraying should be used. If the trees are being sprayed from both the ground and the tower, the man on the ground should take all possible pains to spray the inside of the tree thoroughly and then the lower portions of the outside of the tree. The man on the tower should thoroughly spray the upper parts of the tree. If the trees are sprayed on one side and later on the other, every precaution should be taken to see that the applications overlap.

To facilitate spraying, a light pruning of badly cankered or crowded branches and the removal of all dead wood are advisable.

Susceptible varieties should be sprayed every year regardless of crop to prevent canker formation. This not only applies to old trees but also to young orchards.

Young orchards should be carefully inspected for the occurrence of blotch cankers on the trunks and large limbs. If present, these cankers should be cut out in the early spring. Small limbs and spurs bearing cankers should be pruned out. Cankers on larger branches should be shaved off with a sharp knife; the cuts should be deep enough to remove all of the brown discolored bark tissue, but not deep enough to injure the cambium. The cuts should extend half an inch or more beyond the visible margin of the canker, particularly at the sides of the canker. Ordinarily no disinfectant or wound dressing should be necessary. Because cankers are frequently overlooked, a reinspection and repetition of the process one year and two years later are necessary. The blotch sprays should be applied annually in such orchards.

Orchardists should carefully examine nursery stock for the presence of blotch cankers and should reject shipments containing any infected trees.

Nurserymen should reject apple seedlings bearing blotch cankers and should select bud-sticks only from blotch-free or sprayed trees. Nurserymen and seedling growers should apply the blotch sprays in their plantings. Varieties susceptible to blotch should not be used as stocks.

Susceptible varieties should not be planted in or near orchards already infested with blotch.

The wild crab apple may be a source of blotch infection and such trees near orchards should be destroyed.

Old badly cankered trees of such mediocre varieties as Northwestern and Mann may be the source of fruit infection for many near-by trees of other varieties and might profitably be destroyed.

Suckers and watersprouts are very subject to blotch canker and serve as reservoirs of infection. For this reason these should be pruned out annually.

Diseased trees in a weakened condition should receive applications of nitrate of soda at the rate of five pounds per tree, or sulfate of ammonia, four pounds per tree, broadcasted in a circle beneath the tips of the branches early in the spring.

LITERATURE CITED

1. **Anderson, H. W.** The northern advance of apple blotch and how it may be checked. Trans. Ill. Hort. Soc. **54**:234-237. 1920.

2. **Beach, Frank H.** The control of apple blotch. Ohio State Univ. Agr. Ext. Bulletin 15, no. 8:1-15. 1919-1920.

3. **Brock, W. S.** The report of spraying investigations for the season of 1919. Trans. Ill. Hort. Soc. **53**:130-137. 1919.

4. **Brock, W. S.** A report of field experimental work in 1920. Trans. Ill. Hort. Soc. **54**:184-190. 1920.

5. **Brock, W. S.** The control of blotch and scale. Trans. Ill. Hort. Soc. **56**:432-446. 1922.

6. **Freienmuth, William.** Blister canker and apple blotch. Bien. Rep. Kansas State Hort. Soc. **36**:140-144. 1922.

7. **Gardner, Max W.** Origin and control of apple blotch cankers. In press, Jour. Agr. Research. Abs. in Phytopath. **12**:55. 1922, and **13**:44. 1923.

8. **Guba, E. F.** Effect of dormant lime sulfur upon the control of apple blotch. Science **53**:484-485. 1921.

9. **Gunderson, A. J.** Field experiments in spraying apple orchards for the control of apple blotch. Ill. Agr. Exp. Sta. Bul. 222:551-575. 1919.

10. **Lewis, D. E.** The control of apple blotch. Kan. Agr. Exp. Sta. Bul. 196:521-574. 1913.

11. **M'Cormack, Edna F.** Fungous diseases of the apple. Ann. Rep. Ind. State Entomologist **3** (1909-1910):128-165. 1910.

12. **Roberts, John W.** Apple blotch and its control. U. S. Dept. of Agr. Bul. 534:1-11. 1917.

13. **Roberts, John W.** The apple blotch and bitter-rot cankers. Phytopath. **10**:353-357. 1920.

14. **Scott, W. M.** and **Rorer, James Birch.** The relation of twig cankers to the Phyllosticta apple blotch. Proc. Benton County Hort. Soc. (Bentonville, Ark.) Aug. 8, 1907. p. 1-6.

15. **Scott, W. M.** and **Rorer, James B.** Apple blotch, a serious disease of southern orchards. U. S. Dept. of Agr. Bur. Plant Industry Bul. 144:1-23. 1909.

16. **Sheldon, J. L.** Concerning the relationship of Phyllosticta solitaria to the fruit blotch of apples. Science **26**:183-185. 1907.

17. **Wallace, Frank N.** The dormant or winter spray. Ann. Rep. Ind. State Entomologist **9** (1915-1916):53-55. 1917.

18. **Walton, R. C. and Orton, C. R.** Time of apple blotch infection for 1922 in southern Pennsylvania. Abs. in Phytopath. **13**:11-12. 1923.